ABCs of EDCs

Endocrine Disrupting Chemicals

Results from a Regional Science Forum for the Mid-Atlantic (November 2006)

Background

In the fall of 2006, the Mid-Atlantic awoke to news reports of male fish bearing eggs found within several Potomac River tributaries. Just as in similar cases from other areas, scientists suspect that the high incidence of an intersex condition might be linked to the presence of chemicals in the water – specifically, endocrine disrupting compounds (EDCs). These chemicals, derived from synthetic and natural sources, mimic or alter hormonal activities. The sources, types, and functions of EDCs are highly complex; consequently, their potential biological and ecological impacts have repeatedly fueled scientific concern, public debate, and media attention. To better ascertain the appropriate level of concern that Chesapeake Bay jurisdictions should have for these compounds, and the effects they might have on citizens and the environment, the Chesapeake Research Consortium (CRC), Mid-Atlantic Water Program (MAWP), and Metropolitan Washington Council of Governments (COG) convened a one-day, scientific forum in November 2006.

Presentations at this forum reviewed what is known about endocrine disrupting compounds, their local and national impacts, observed levels in the Chesapeake Bay's watershed, potential threats to human health and living resources, and possible mitigation strategies to address the accumulation of these materials. Information presented in this fact sheet only reflects the data and discussions presented at the workshop. This fact sheet does not address the potential sources or impacts of EDCs from food, drinking water, air or other media. Also, this workshop did not attempt to quantify either the absolute or relative risk from any of these sources compared to other environmental pollutants. This fact sheet therefore should be viewed as being informative rather than definitive regarding these compounds and their potential implications for the Bay watershed.

What We Know & Don't Know

Endocrine disrupting compounds may affect normal development, metabolism, and reproduction in animals by mimicking or blocking hormone production or activity. Many naturally produced compounds in animals and plants have endocrine activity. Man-made pesticides, herbicides, and synthetic products can have similar activity that may disrupt aquatic and terrestrial life.

Examples of Man-Made EDCs

- Anti-bacterial or anti-fungal compounds
- Anabolic steroids
- Detergents
- Pharmaceuticals
- Pesticides
- Plasticizers
- Flame retardants
- Rocket fuels
- Poly-chlorinated biphenyl compounds (PCBs)

Effects on Human Health

Potential Links to Obesity:
These mature female mice, both from the same strain, had the same diet and activity levels. The mouse on the right, however, was exposed to the endocrine disrupting compound DES. During neonatal development, the mouse was given a dose of DES at 0.001 mg/day for days 1-5 (Newbold et al., 2005). Exposure of mice to DES during critical windows of development is clearly linked to obesity later in life.

Human health effects remain a major concern, but definitive cause and effect relationships have not been clearly established yet. While research on humans has been limited, results from current animal research suggest the potential for adverse outcomes, including altered ovarian and testicular development, male infertility, impaired cognitive development, cancers (non-Hodgkin's lymphoma, leukemia in children, elevated prostate cancer risk), Type II diabetes, obesity and immunosystemic disorders (Myers). Research also indicates that *in utero* exposure to EDCs may cause increased susceptibility or impairment during adulthood and/or permanent generational impacts. Since the environment contains mixtures of these compounds, researchers are beginning to study the synergistic impacts of exposure to combined compounds. In general, little is known about how these mixtures and exposure to low doses of single compounds, affect human health. Results from continued animal research could indicate the potential impacts of these chemicals on human development, health, and reproduction.

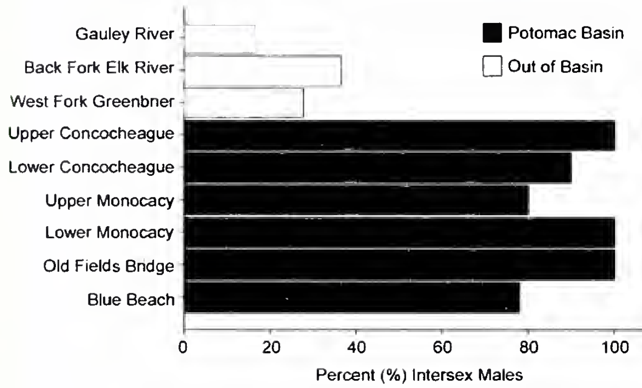
Effects on the Environment

The effects of endocrine disruptors vary greatly, often as a function of species, habitat, and stage of life cycle exposed. Much research has concentrated on the effects in fish, where adverse outcomes include various degrees of intersex phenotypes (e.g. males with eggs, females with testis), reduced sperm count and motility, and reduced nest guarding (Blazer). Studies on amphibians have also shown increased hermaphroditism and enhanced sensitivity to disease, while avian research indicates that exposure of some EDCs at common environmental levels can delay maturation, alter reproductive behavior, and reduce egg production and fertility (Hayes et al., 2006; Ottinger).Impacts on estuarine plankton and benthic food webs have been frequently overlooked. But studies show that synthetic chemicals, like the pesticides endosulfan and atrazine, can cause lower densities of vital aquatic life, including phytoplankton, planktonic copepods, and grass shrimp (Green, 2003). Research on atrazine further indicates that this compound reduces survival of second generation copepods and growth in oysters and clams (Scott).

Endocrine Disruptors in the Mid-Atlantic

In areas with elevated EDCs in surface or groundwater, most research has focused on discharge from agricultural operations that confine large aggregations of livestock (CAFOs) or sewage treatment facilities (WWTPs) that manage wastewater from concentrated human populations. EDC concentrations in the Mid-Atlantic have been assessed in a number of studies over the last decade. Analyses of poultry litter from MD's Eastern Shore have been found to contain 165 and 50 ng/g of 17-ß estradiol and testosterone, respectively. Following litter application in the spring, 90-370 ng estradiol/L was detected in runoff from no-till cropland following the first spring rains in 2000 and 2002. Levels in the retention pond receiving the runoff declined from approximately 80 ng/L to about 18 ng/L over 3-8 weeks (Yonkos and Fisher). However, considering that levels as low as 1 ng/L have resulted in male fish synthesizing egg yolk, these levels are a concern (Jobling et al., 2006).

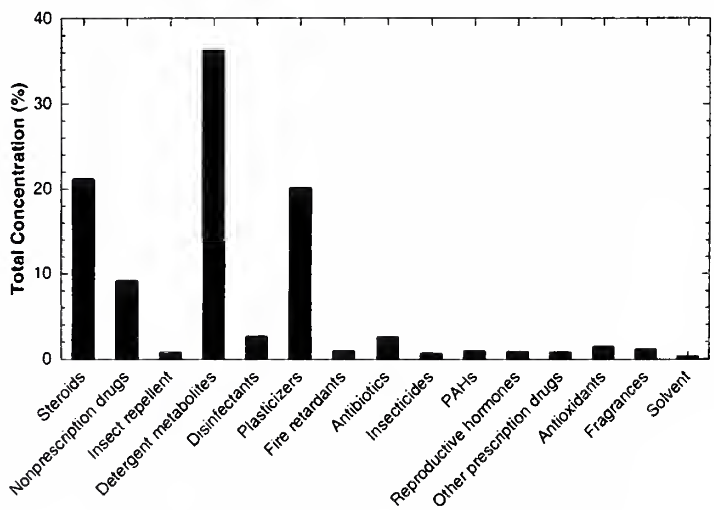
Prevalence of Intersex Male Fish In & Around the Potomac Basin



(Figure courtesy of V. Blazer)

Research on the anti-microbial chemicals triclosan and triclocarban showed levels from >10 to almost 7,000 ng/L in Baltimore streams (Halden and Paull, 2004 and 2005). Research on North American bullfrogs show that triclosan levels as low as 30 ng/L can modify gene expression of thyroid hormone receptors in *in vitro* cell assays (Veldhoen et al., 2006). Other studies estimate that 48% of the triclosan and 74% of the triclocarban mass entering local sewage treatment plants is later applied as biosolids to agricultural lands (Heidler et. al, 2006 and 2007). These compounds are also found in Chesapeake Bay sediments at levels exceeding 1 mg/kg (Halden, 2006). Assessments of similar biosolids and river sediment enrichments in VA were found to contain flame-retardant compounds that mimic thyroidal hormones (Hale et al., 2001; LaGuardia). These polybrominated diphenyl ethers were also found to bioaccumulate in fish.

Pharmaceuticals, Hormones, and Organic Waste Contaminants in U.S. Stream



Conventional waste water treatment focuses mostly on lowering pathogenic bacteria to minimize threats to human health and reduce nitrogen and phosphorus levels that cause excessive algal growth and low dissolved oxygen in aquatic environments. While conventional treatment process have shown a somewhat limited ability to remove some of these trace organics, plants that utilize nitrification/denitrification and other advanced processes have proven to be much more effective, although at higher costs (LaGuardia; Mills). Since endocrine disruptors are mostly organics, the chemicals are fairly resistant to the technologies developed to treat pathogens and inorganic compounds at wastewater facilities. Anaerobic processing is a model example of a wastewater treatment technology that is extremely effective in reducing environmental impairment from nitrogen compounds, but largely inadequate for treating EDCs. This process diverts substantial amounts of biologically-active nitrogen away from effluent-receiving waters by converting the compounds into inert nitrogen gas. Yet, this treatment removes less than 10% of reactive EDCs, concentrating the remaining >90% in biosolids.

Solutions to Endocrine Disruption

Research indicates promising strategies to mitigate transmission of EDCs into soil and water. This factsheet, and the associated forum held on November 16, 2006, only discussed exposure through watershed processes – and it is important to recognize that transmission of these compounds can occur through other media. While more research and economic assessments are required, some possible additions to advanced treatment at WWTPs include photolysis, ozonation, and chemical oxidation. WWTPs can also facilitate the degradation of the EDCs accumulated in biosolids by maintaining aerobic soils (Jacobsen et al., 2005). For agricultural facilities, like CAFOs, composting at elevated temperatures for long periods (>120°F for 139 d) can remove 84-90% of the concentrated EDCs (Millner and Hakk). However, temperature regulation, carbon and nitrogen supply, acreage, and manpower may limit practical adoption of this strategy.

Researchers are still working to better understand how these compounds affect endocrine function. As the number of confirmed EDCs continues to expand, research and management organizations will require technologies and strategies for greater detection, treatment, and remediation. These agencies will need to assess the toxicity of single compounds, compound mixtures, and any degradation products, while also working to understand how acute and chronic exposure affects endocrine functioning two to three generations after contact. The fate of EDCs in waste treatment by-products, such as biosolids, should also be determined to assure public confidence in crops and animals associated with EDC-treated soils. To assure that cumulative evidence governs regulatory decisions on product use, alternative animal models must be accepted by the assessment and regulatory community.

Ultimately, the best means for controlling EDC transmission is to reduce the production and inclusion of synthetic compounds in commercial products (Halden; Myers). Doing so will minimize future EDC loads to the watershed will allows historically deposited compounds to attenuate to safe or non-detectable levels.

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Established in 1972, the Chesapeake Research Consortium is an incorporated, non-profit association of six academic and research institutions from the Chesapeake Bay region. Its goal is to foster multi-institution, multi-disciplinary research for the Bay, its watershed, and the coastal zone. Through reporting, workshops, science forums, the web, and discussions, it communicates this information to regional, national, and international organizations and agencies for effective science-based management of our air, lands, waters, and living resources.

Established in 1957, the Metropolitan Washington Council of Governments is an independent, nonprofit association of more than 250 local, state, and federal elected officials representing 21 local governments in the region. COG's mission is to enhance the quality of life and competitive advantages of our region by providing a forum for consensus building, implementing intergovernmental policies and being a resource of technical information on a wide variety of issues including the environment.

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Hood College is a comprehensive college in Frederick, Maryland offering bachelor degrees in 27 major fields of study and 13 master's degree programs. Its Biology Department provides a regional center for teaching, learning, and research in the areas of environmental biology and biomedical science.

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